



## Eastern Cave- and Crevice-Dwelling Bats Potentially Impacted by USACE Reservoir Operations

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**PURPOSE:** This document is one in a series of technical notes concerning species that are potentially impacted by U.S. Army Corps of Engineers (Corps) reservoir operations. These technical notes are products of the Corps Ecosystem Management and Restoration Research Program (EMRRP) work unit titled "Reservoir Operations – Impacts on Target Species" (Dickerson, Martin, and Allen 1999; Kasul, Martin, and Allen 2000). This note provides information on six species of forest bats that roost in caves or cave-like structures (Figure 1) and potentially occur



Figure 1. Numerous bat species depend on caves as roost sites in the eastern United States

on Corps projects in the eastern United States. The status of each species is given and information is provided on the impacts responsible for population declines. General habitat requirements and management needs are described for this group of bats. More specific details on status, distribution, habitat, behavior, reproduction, food habits, impacts, and management are provided in separate technical notes on individual species (ERDC Technical Notes EMRRP-SI-25 through EMRRP-SI-27 and EMRRP-SI-29). Links to these additional technical notes can be found on page 8.

**BACKGROUND:** Bats represent an important faunal component of most forested ecosystems and can contribute significantly to the biodiversity of a region. Approximately 20 species of bats occur in forested areas of the eastern United States; all of these species are insectivorous and very beneficial because they consume large quantities of moths, flies, mosquitoes, beetles, and other nocturnal invertebrates. In fact, most bats eat more than 50 percent of their body weight each night (Harvey, Altenbach, and Best 1999). Although the ecological and economic importance of bats has been documented in numerous studies, they are often misunderstood, and populations may be intentionally destroyed or indirectly affected by habitat loss and disturbance of roost sites. Bats are extremely important worldwide, but many species are in serious decline and in danger of extinction unless steps are taken to protect their populations and prime habitats.

Several eastern cave- or crevice-dwelling bats have been federally designated as endangered, threatened, or species of concern (Table 1). The Indiana bat (*Myotis sodalis*) is federally listed as

endangered and is nearly extinct over much of its former range in the Northeast. The main breeding and hibernating areas for the species appear to be associated with major cavernous limestone regions in the midwestern and eastern states, and more than 85 percent of the population hibernates at only seven locations in Missouri, Kentucky, and Indiana. The federally endangered gray bat (*M. grisescens*) occurs in cavernous regions of Arkansas, Missouri, Kentucky, Tennessee, and Alabama, with occasional colonies in adjacent states. The southeastern myotis (*M. austroriparius*) occurs in scattered locations throughout the northeastern and east-central states and is designated as a species of concern. The eastern small-footed bat (*M. leibii*), also a species of concern, hibernates in caves and mines in the northeastern and east-central states. The Townsend's big-eared bat (*Corynorhinus townsendii*) includes two distinct subspecies in the East, both of which are endangered; these are the Ozark big-eared bat (*C. t. ingens*) and Virginia big-eared bat (*C. t. virginianus*). Rafinesque's big-eared bat (*C. rafinesquii*) is a federal species of concern and is considered a sensitive species in several states. The state protection status of species not federally listed is summarized in Table 2, located at the end of this report. Range maps are provided in Figures 2a-2f.

**Table 1**  
**Summary Status of Eastern Cave Bats Potentially Impacted by USACE Reservoir Operations**

| Common Name                                   | Scientific Name   | Protection Status <sup>1</sup>               |
|---|---|--|
| Indiana bat                                   | <i>Myotis sodalis</i>   | Federally endangered                         |
| Gray bat                                      | <i>Myotis grisescens</i>  | Federally endangered                         |
| Ozark big-eared bat<br>Virginia big-eared bat | <i>Corynorhinus townsendii ingens</i><br><i>Corynorhinus townsendii virginianus</i> | Federally endangered<br>Federally endangered |
| Eastern small-footed bat                      | <i>Myotis leibii</i>  | Federal species of concern                   |
| Southeastern myotis                           | <i>Myotis austroriparius</i>  | Federal species of concern                   |
| Rafinesque's big-eared bat                    | <i>Corynorhinus rafinesquii</i>   | Federal species of concern                   |

<sup>1</sup> Indicates priority level of protection. Refer to Table 2 for details.

Numerous other bat species are known to use caves, mines, culverts, and similar structures, primarily in the western United States (Tuttle and Taylor 1998). The endangered greater long-nosed bat (*Leptonycteris nivalis*) and lesser long-nosed bat (*L. curasoae yerbabuenae*) are nectar and fruit-eating species that inhabit caves and mines in the Southwest. Western species of concern that use caves and mines include the ghost-faced bat (*Mormoops megalophylla*), California leaf-nosed bat (*Macrotus californicus*), Mexican long-tongued bat (*Choeronycteris mexicana*), western small-footed bat (*Myotis ciliolabrum*), western long-eared bat (*M. evotis*), Arizona bat (*M. lucifugus occultus*), fringed bat (*M. thysanodes*), cave bat (*M. velifer*), long-legged bat (*M. volans*), Yuma bat (*M. yumanensis*), Allen's big-eared bat (*Idionycteris phyllotis*), Pacific big-eared bat (*C. t. townsendii*), and western big-eared bat (*C. t. pallescens*). Eight additional United States species use caves and cave-like structures as roosting habitat (Tuttle and Taylor 1998; Harvey, Altenbach, and Best 1999). Discussion of all of these species is beyond the scope of this technical note. However, general information provided on impacts and management strategies apply to all forest-dwelling bats that use caves as summer or winter roost sites.

**Table 2**  
**State Protection Status of Eastern Cave Bats**

| States                 | Indiana bat <sup>1</sup> | Gray bat <sup>1</sup> | Townsend's big-eared bat |                       | Eastern small-footed bat | Southeastern bat | Rafinesque's big-eared bat |
|------------------------|--------------------------|-----------------------|--------------------------|-----------------------|--------------------------|------------------|----------------------------|
|                        |                          |                       | Ozark <sup>1</sup>       | Virginia <sup>1</sup> |                          |                  |                            |
| Midwest/Central States |                          |                       |                          |                       |                          |                  |                            |
| IL                     | SE                       | SE                    |                          |                       |                          | SE               | SE                         |
| IN                     | SE                       | SE                    |                          |                       |                          | SE               | SSC                        |
| IA                     | SE                       |                       |                          |                       |                          |                  |                            |
| KS                     |                          | SE                    |                          |                       |                          |                  |                            |
| MI                     | SE                       |                       |                          |                       |                          |                  |                            |
| MO                     | SE                       | SE                    | SE                       |                       | SE                       | SSC              | SSC                        |
| MN                     |                          |                       |                          |                       |                          |                  |                            |
| OH                     | SE                       |                       |                          |                       | SE                       |                  | SSC                        |
| OK                     | SE                       | SE                    | SE                       |                       | SSC                      | SSC              | SSC                        |
| ND                     |                          |                       |                          |                       | SSC                      |                  |                            |
| TX                     |                          |                       |                          |                       |                          |                  | ST                         |
| WI                     |                          |                       |                          |                       |                          |                  |                            |
| Southeast              |                          |                       |                          |                       |                          |                  |                            |
| AL                     | SP                       | SP                    |                          |                       |                          | SP               | SP                         |
| AR                     | FE <sup>2</sup>          | FE <sup>2</sup>       | FE <sup>2</sup>          |                       | SSC                      | SSC              | SSC                        |
| FL                     |                          | SE                    |                          |                       |                          | SSC              | SSC                        |
| GA                     | SE                       | SE                    |                          |                       | SSC                      | SSC              | SSC                        |
| KY                     | SE                       | SE                    |                          | SE                    | ST                       | SE               | SSC                        |
| LA                     |                          |                       |                          |                       |                          |                  |                            |
| MS                     | SE                       | SE                    |                          |                       |                          |                  | SSC                        |
| NC                     | SE                       |                       |                          | SE                    | SSC                      | SSC              | SSC/PST <sup>3</sup>       |
| SC                     | SE                       |                       |                          |                       | ST                       | ST               | SE                         |
| TN                     | SE                       | SE                    |                          |                       | D                        | SSC              | SSC/D                      |
| Northeast              |                          |                       |                          |                       |                          |                  |                            |
| CT                     |                          |                       |                          |                       | SSC                      |                  |                            |
| DE                     |                          |                       |                          |                       | SSC                      |                  |                            |
| ME                     |                          |                       |                          |                       | SSC                      |                  |                            |
| MD                     | SE                       |                       |                          |                       | SSC                      |                  |                            |
| MA                     |                          |                       |                          |                       | SSC                      |                  |                            |

(Continued)

<sup>1</sup> The federally endangered status of these species takes precedence over state listings.

<sup>2</sup> State uses federal status as their designation.

<sup>3</sup> Proposed state status is threatened.

D = Deemed in need of management  
FE = Federally endangered species  
FT = Federally threatened species  
SE = State endangered species  
ST = State threatened species  
SP = State protected  
SSC = State species of special concern

| Table 2 (Concluded)   |                          |                       |                          |                       |                          |                  |                            |
|-----------------------|--------------------------|-----------------------|--------------------------|-----------------------|--------------------------|------------------|----------------------------|
| States                | Indiana bat <sup>1</sup> | Gray bat <sup>1</sup> | Townsend's big-eared bat |                       | Eastern small-footed bat | Southeastern bat | Rafinesque's big-eared bat |
|                       |                          |                       | Ozark <sup>1</sup>       | Virginia <sup>1</sup> |                          |                  |                            |
| Northeast (Concluded) |                          |                       |                          |                       |                          |                  |                            |
| NH                    |                          |                       |                          |                       | SE                       |                  |                            |
| NJ                    | SE                       |                       |                          |                       | SSC                      |                  |                            |
| NY                    | SE                       |                       |                          |                       | SSC                      |                  |                            |
| PA                    | SE                       |                       |                          |                       | ST                       |                  |                            |
| RI                    |                          |                       |                          |                       |                          |                  |                            |
| VT                    | SE                       |                       |                          |                       | ST                       |                  |                            |
| VA                    | SE                       | SE                    |                          | SE                    | SSC                      | SSC              | SE                         |
| WV                    | FE <sup>2</sup>          | FE <sup>2</sup>       |                          | FE <sup>2</sup>       | SSC                      |                  | SSC                        |
| Total States          | 22                       | 14                    | 3                        | 4                     | 22                       | 13               | 17                         |

A recent survey indicated that bats were a concern on several Corps projects in the East (Kasul, Martin, and Allen 2000). Ten projects in six Districts reported the occurrence of protected bat species on their projects. Numerous other projects likely support substantial bat populations, but adequate surveys have not been conducted to identify all projects harboring bats. Records maintained by Headquarters, USACE, show that gray bats and/or their habitats are being managed as part of recovery plan efforts on 15 projects in Kentucky, Tennessee, Missouri, Arkansas, and Kansas; and Indiana bat habitat is being managed on two projects in Kentucky.<sup>1</sup> Although several projects have implemented management measures to protect caves used by Indiana and gray bats, there is potential for including forest bats in management programs at many Corps projects (Martin 2000).

**HABITAT REQUIREMENTS:** More than half of the 45 bat species in North America roost in caves or abandoned mines (Ducummon 2000), and all six of the endangered bat species/subspecies in the conterminous United States depend on caves or mines (Currie 2000). All of the species noted above typically depend on caves, caverns, mines, or tunnels for at least part of the year. Indiana bats typically winter in limestone caves and abandoned mineshafts but form maternity roosts under loose bark and in hollow trees (Figure 3). Gray bats are year-round cave residents and migrate between cold hibernation caves (hibernacula) in winter and warm caves during the summer. The southeastern myotis (Figure 4a) is known to roost in caves, hollow trees, and a variety of artificial structures. The eastern small-footed bat hibernates in caves or mines but may inhabit buildings or caves during the summer. In the eastern states, Townsend's big-eared bats have been reported almost exclusively from caves. Rafinesque's big-eared bats tend to hibernate in caves, mines, and artificial habitats (e.g., cisterns and wells) in the northern part of their range but use hollow trees and structures such as abandoned buildings and bridges in the Coastal Plain (Figure 4b) (Barbour and Davis 1969; Harvey 1992; Harvey, Altenbach, and Best 1999).

<sup>1</sup> Personal Communication, July 2000, Denise White, Headquarters, U.S. Army Corps of Engineers, Washington, DC.



Figure 2a. Indiana bat

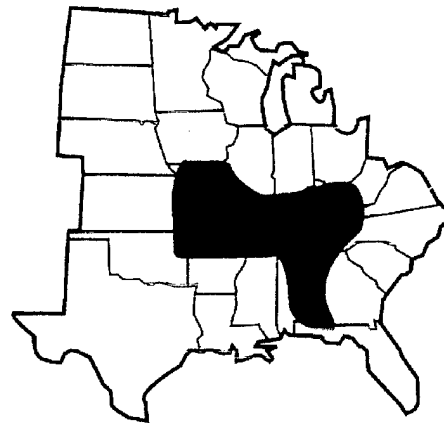


Figure 2b. Gray bat

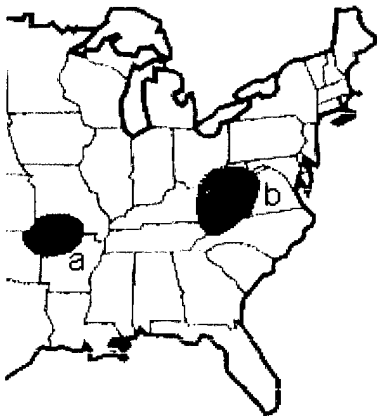


Figure 2c. (a) Ozark big-eared bat;  
(b) Virginia big-eared bat



Figure 2d. Small-footed bat



Figure 2e. Southeastern myotis

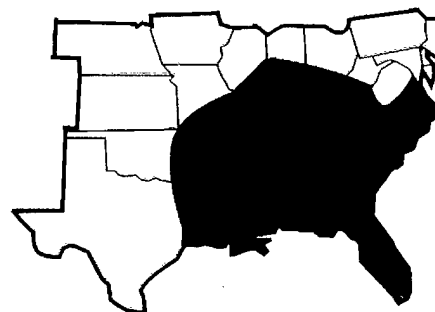


Figure 2f. Rafinesque's big-eared bat

Figure 2. Range maps of bat species addressed in this technical note (after Harvey, Altenbach, and Best (1999))



Figure 3. Indiana bats winter in caves but form summer maternity colonies under loose bark and in hollow trees



Figure 4. The southeastern myotis (left) and Rafinesque's big-eared bat (right) roost in caves, hollow trees, and a variety of artificial structures in southeastern forests

Mature forested areas surrounding caves or located between caves are extremely important to eastern bat species, and wooded riparian corridors and aquatic areas are critical as foraging sites. All species of southern forest bats are at least partially dependent on forests for shelter, roost sites, and/or foraging areas (Harvey and Saugey 2001). Bats are often closely associated with riparian areas because of their need to drink surface water during evening activity periods, and many species congregate along streams and pools where water is available. Bats also use riparian areas as foraging habitat and movement corridors. For example, summer maternity colonies of Indiana bats are most often located in floodplain deciduous forests or upland stands adjacent to riparian or floodplain forests (Garner and Gardner 1992, U.S. Fish and Wildlife Service 1999). Summer colonies of gray bats inhabit areas where streams, lakes, or reservoirs are reasonably close to roosting sites and maternal caves (Tuttle 1976, Gore 1992). When tree roosts are used, most species require large-diameter trees with large central cavities. Maternity roost sites for Indiana bats include hollow trees and spaces under the loose bark of a variety of tree species (Humphrey, Richter, and Cope 1977; Gardner, Garner, and Hofmann 1991; Kurta et al. 1992). Refer to species profiles for additional information on habitat, behavior, reproduction, and food habits of these species.

**IMPACTS:** The long-term decline of bat populations in the eastern United States is due to several natural and human-induced factors. Although natural events such as flooding, cave-ins, and freezing occasionally impact bats, human disturbances are the main causes of decline in most species (Harvey, Altenbach, and Best 1999). Direct human impacts include vandalism and intentional eradication (Tuttle 1997), cave exploration (Harvey, Altenbach, and Best 1999), and cave commercialization (Brady et al. 1982). Disturbances to hibernating bats and maternity colonies are especially destructive to bat populations. Environmental impacts include physical modifications to cave entrances, deforestation and land clearing, deterioration of riparian habitats, stream modification, strip-mining, excessive use of pesticides, and urbanization (Martin 2000).

Cave-dwelling forest bat populations are potentially impacted on Corps projects where caves and mines are not monitored and protected from vandalism. Specific actions have been taken on projects where endangered species are known to occur, especially where there are known wintering colonies of Indiana and gray bats. Corps actions undertaken for these species include fencing known roost sites (primarily caves), installing and maintaining gates at the entrances to maternity caves and hibernacula, displaying signs at cave entrances to explain the importance of protecting bats, and preventing flooding of roost sites (Martin 2000). Bat populations are also potentially impacted by management activities where their habitat needs have not been considered in the project's operational management plan. For example, forest management practices that don't emphasize snag retention and maintaining an adequate supply of mature hardwood trees (especially those with exfoliating bark) could be detrimental to existing bat populations. Timber management practices probably have the most significant impact on forest bats and their habitats (Harvey and Saugey 2001). Also, the location of high-intensity recreation areas near roost sites could be harmful, especially to maternal colonies.

**MANAGEMENT:** Surveys of potential habitat should be conducted to document the occurrence of bat species and to gain a better understanding of their distribution, ecology, and habitat use in an area. Potential roost sites that should be surveyed and evaluated on Corps project lands include caves, caverns, mines, tunnels, old wells, cisterns, and bridges. Management strategies for the conservation of eastern bats include protection of maternity and wintering cave sites, riparian zone

restoration, maintenance of adequate mature timber stands, and provision of artificial roost sites for some species (Martin 2000). Bat roosts in caves and mines should be protected from human disturbance by fencing, posting signs at roost sites, and gating entrances to prevent human entry, if necessary. Although gating has become a major management tool, construction of gates should only be undertaken with the aid of expert consultation and supervision. The American Cave Conservation Association provides general information on constructing bat gates, and detailed designs are updated annually (Tuttle and Taylor 1998).

Foraging habitat should be protected by preserving the water quality of foraging sites, leaving forests associated with foraging areas intact near roost caves, and maintaining the vegetation surrounding cave entrances to provide protection during nocturnal emergence (Brady et al. 1982; Adam, Lacki, and Barnes 1994). Since hollow trees provide roost sites for most species of eastern bats, forest management should ensure an adequate supply of mature timber and snag trees (Martin 2000). Because of the importance of riparian areas to bat ecology, riparian restoration should be considered for bat conservation and habitat improvement at Corps projects. Modifying bridge designs and providing artificial roost sites may be applicable at some projects. Habitat improvements should be examined with respect to the project operational management plan, and existing timber management and wildlife habitat management practices should be evaluated to determine their compatibility with bat management needs.

Although natural vegetation and structures (e.g., caves, rock crevices) usually provide optimal roost sites for most bat species, many species have been reported to use a variety of artificial structures, especially where preferred habitat has been modified or depleted. Big brown bats (*Eptesicus fuscus*), little brown bats (*Myotis lucifugus*), and evening bats (*Nycticeius humeralis*) are species most often reported from buildings and other artificial structures in the eastern United States; the eastern pipistrelle (*Pipistrellus subflavus*), silver-haired bat (*Lasionycteris noctivagans*), southeastern myotis, Rafinesque's big-eared bat, and Brazilian free-tailed bat (*Tadarida brasiliensis*) will also use buildings, culverts, bridges, and similar structures in the East. Many species of bats are known to roost beneath bridges and in culverts. Bridges constructed of prestressed concrete girder spans, cast-in-place spans, or steel I-beams are preferred (Keeley and Tuttle 1999, Lance et al. 2001). Although our endangered bat species have rarely been reported to use man-made structures, a maternity colony of Indiana bats was recently discovered in the attic of an old frame country church in south-central Pennsylvania (Butchkoski and Hassinger 2001). Managers should emphasize the protection and management of natural roost sites, but consideration should also be given to providing appropriate artificial structures, especially where natural sites are lacking.

**SPECIES PROFILES:** Profiles of the endangered bat species noted above are published as separate technical notes and linked to this technical note. The titles and publication numbers of the profiles are as follows:

**Cave- and Crevice-Dwelling Bats on USACE Projects:**

|                          |                |
|--------------------------|----------------|
| Gray Bat                 | TN EMRRP-SI-25 |
| Indiana Bat              | TN EMRRP-SI-26 |
| Townsend's Big-eared Bat | TN EMRRP-SI-27 |
| Southwestern Myotis      | TN EMRRP-SI-29 |



**SUMMARY:** Bats represent an important faunal component of most forested ecosystems and can contribute significantly to the biodiversity of a region. Approximately 20 species of bats occur in forested areas of the eastern United States; all of these species are insectivorous and very beneficial because they consume large quantities of moths, flies, mosquitoes, beetles, and other nocturnal invertebrates. Although the ecological and economic importance of bats has been documented in numerous studies, they are often misunderstood, and populations may be intentionally destroyed or indirectly affected by habitat loss and disturbance of roost sites. Bats are extremely important worldwide, but many species are in serious decline and in danger of extinction unless steps are taken to protect their populations and prime habitats. Management strategies for the conservation of eastern bat species include protection of maternity and wintering cave sites, riparian zone restoration, preservation of adequate mature timber stands, maintenance of snags (dead and dying trees with cavities and/or exfoliating bark), and provision of artificial roosts for some species. Bat roosts in caves and mines should be protected from disturbance by fencing, posting signs at roost sites, and gating entrances to prevent human entrance, if necessary. Foraging habitat should be protected by maintaining or improving the water quality of foraging sites, leaving forests intact near roost caves, and maintaining a vegetative buffer around cave entrances to provide protection during nocturnal emergence. Because of the importance of riparian areas to bat ecology, riparian restoration should include strategies for bat conservation and habitat improvement at Corps projects.

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